Visual Planner: Beyond Prerequisites, Designing an Interactive Course Planner for a 21st Century Flexible Curriculum

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Abstract
In the 21st century knowledge economy there is a growing need for the types of creative thinkers who can bridge the engineering mindset with the creative mindset, combining multiple types of skills. New economies will need workers who have "diagonal" skill sets, who can develop systems and content as an integrative process. This requires a new type of training and curriculum. In the newly formed "Digital Culture" undergraduate program at ASU, we attempt to support new types curricula by structuring differently the way students move through courses. With a constantly shifting and changing curriculum, structuring course enrollment using class prerequisites leads to fixed and rigid pathways through the curriculum. Instead, Digital Culture structures course sequences based on the students accumulation of abstract "Proficiencies" which are collected by students as they complete courses, and which act as keys to unlock access to higher level course. As a student accumulates more and more of these proficiencies, they are increasingly able to unlock new courses. This system leads to more flexible and adaptive pathways through courses while ensuring that students are prepared for entrance into more advanced classes. It is however more complicated and requires that students strategically plan their route through the curriculum. In order to support this kind of strategic planning we have designed and deployed a course planning system where
students can simulate various possible paths through the curriculum. In this paper, we show our design process in coming up with our "Digital Culture Visual Planner". This design process starts with a network analysis of how all the Digital Culture courses are interrelated by, visualizing the relationships between proficiencies and courses. A number of possible design directions result from this analysis. Finally we select a single design and refine it to be understandable, useful and usable by new undergraduate Digital Culture majors.

**Author Keywords**
User interface design; visualization; design planning; interdisciplinary curriculum

**ACM Classification Keywords**
H.5.3 [Group and Organization Interfaces]: Web-based interaction.; J.1 [Administrative Data Processing]: Education.

**General Terms**
Design

**Introduction**
In this paper, we present the Digital Culture Visual Planner, a web-based interactive course-planning tool to address the challenge of designing a tool for students to interactively explore various routes through a complex curriculum. This tool must allow students to interactively navigate the complex web of relationships between courses and proficiencies to iteratively discover optimal pathways through future course offerings. This is a complex, multifaceted problem. Any interface design must be simple enough so that undergraduate students can quickly understand how to use the tool, yet complex enough that students can truly explore various future scenarios and visually comprehend the impact of their decisions.

The sections are organized as below: 1. We introduce the Digital Culture educational context and specify the challenge. 2. We present our design strategies for solving problems in this specific context. 3. Finally, we propose our future thoughts and work.

**The Digital Culture Context**
Most academic curricula operate under the model of prerequisites, where completing one course will open access to the next course in a specific series. The Digital Culture curriculum is a new interdisciplinary, undergraduate curriculum developed by the School of Arts, Media and Engineering (AME) and its 15 partnering units at Arizona State University (ASU). Digital Culture aims to train the next generation of cultural creative who must be skilled not only in making creative content, but equally so in designing and creating next generation digital tools and systems. In order to address the inherent interdisciplinary requirements of such a curriculum, we adopted a "proficiency-based" course framework (see figure 1) designed to flexibly move students through customizable course sequences. The curriculum designates a list of 27 important digital culture proficiencies spanning different disciplines including social science, media, humanities, art, science and engineering. These can be thought of not only as actual learned skills and techniques, but also as generic keys or badges which are provided by courses and gathered by students to later unlock access to higher level courses. A single course might provide one or several new proficiencies from this list. When a student successfully completes a course, they receive a few more proficiency keys which add to their personal collection. Higher level courses are open only to

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1<http://digtialculture.asu.edu>
those students who have gathered the specific necessary set of proficiencies for that course.

This method of organizing and planning our students education offers much flexibility but comes at a great price: complexity. Students have to keep track of which proficiency keys they “own”, and strategically gather new proficiencies in order to open up access to certain course pathways they wish to pursue. Instructors and faculty have to decide on what proficiencies each course will require for enrollment as well as which proficiencies will be provided upon completion of each course. Administrators must look at the entire network of course/proficiency relationships to make certain the overall network of courses, linked by proficiency keys, is coherent and free from “islands” and "dead ends”.

Currently, this proficiency-based curriculum relies heavily on face-to-face meetings between students and academic advisors. Each student is required to consult with an academic advisor in order to determine which courses to take next. The advisors are very experienced and familiar with the curriculum. With a small number of students, this face-to-face support is acceptable but as enrollment numbers increase, students will need to be able to explore and plan their own routes through the curriculum. What is needed is an online tool for students to interactively navigate course sequences and build their own optimal paths through courses.

Ideally, this dynamic proficiency-based curriculum offers several advantages compared to the traditional linear course-based curricula. Students can tailor their path through the curriculum to suit their career goals. For example, students who would like to pursue videogame development can take a collection of courses that may differ from other students who dream of being hired by Google or Facebook to help design user interfaces. In practice, achieving this kind of flexibility and customization in the curriculum depends on overcoming several challenges.

**Challenge 1 - Interdisciplinary Program** Both faculty and students who may have been accustomed to their self-contained individual disciplines must now adapt to active and deliberate process of integrating a variety of disciplines into their thinking. This becomes somewhat problematic when students are suddenly required to build educational paths within multiple disciplines that they are not familiar with.

**Challenge 2 - Excessive Choices** The dynamic curriculum provides a wide range choice for students to build their educational paths. Each student makes their own choices when planning their own courses, yet there is no fixed strategy for students to determine an optimal path.

**Challenge 3 - Self-Directed Planning** Students are given the freedom to choose courses and can take into account their own personal backgrounds, interests and career goals; however, they must spend time and energy to keep track of their own collection of proficiencies, requirements and plan several semesters in advance in order to take advantage of the flexible curriculum.

**Design Goal - An Interactive Exploration Tool**
To address the several inherent challenges in operating a curriculum based on proficiencies, we proposed a web-based, interactive course exploration tool to assist Digital Culture undergraduates in customizing their educational paths. We envision a tool whereby a student can track his own progress through the curriculum, make short-term plans and adjustments to course schedules and enrollment, and make long-term plans several semesters in advance.
Our initial design phase consisted of a brief student survey in tandem with a detailed analysis of the complex interrelationships between courses and proficiencies. We created a visualization method for mapping out these course/proficiency relationships and created several large posters illustrating the resulting visual patterns.

**Student Survey**
We interviewed four undergraduates who were preparing to major in Digital Culture. The survey helped us understand our target users, while validating some preconceptions and intuitions. Their feedback can be summarized as follows:

- Students enjoy Digital Culture courses, finding them interesting and practical; however, students are not aware of the overall curriculum structure.
- Students rely heavily on their academic counselors for short and long-term information and advice.
- Students have general ideas about career goals but rarely have concrete plans or knowledge about how to achieve these goals.
- Students are able to schedule courses in the short term but need advising to make long-term plans.

**Visual Analysis and Exploration**
To better understand the proficiency-based curriculum, we analyze course data as a series of graphic charts in order to study the relationship between courses (please see Figure 2). Specifically, in each table, we arranged proficiencies on the X axis and courses along the Y axis. Within this frame of reference, we mark out which proficiencies are required and provided by which courses. We mark a required proficiency as a circle and a provided proficiency as a triangle. We can start to determine which courses and proficiencies are lacking sufficient connections to other courses. Some courses actually lack any possible pathways to them and are labeled "critical" in red. In practice, no student could ever enroll in one of these problem "critical" courses. Similarly, courses with too few pathways to them are labeled "warning" in yellow. Healthy and sufficiently linked proficiency/courses are labeled "free" in green. See Table 1.

**Table 1: Visual Metaphor**

<table>
<thead>
<tr>
<th>Course/Proficiency</th>
<th>Critical</th>
<th>Warning</th>
<th>Free</th>
<th>Texture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical</td>
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<td></td>
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<tr>
<td>Warning</td>
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<td>Free</td>
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<td>Texture</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Connection</th>
<th>Outgoing</th>
<th>Incoming</th>
<th>Critical</th>
<th>Free</th>
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<tbody>
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These very complex charts and plots gave us a good sense of the design problem space but are too complex to present information to end users. The analysis gave us a good overview but did not suggest any obvious visual designs for moving forward with user interfaces.

**Visual Planner Introduction**
With a good visual overview of the relationships between courses and proficiencies, the next step is to design an online course-planning tool for the students to plan their
enrollment in future courses. The main requirements for the tool are as follows:

- It must provide a way for students to track their personalized inventory of proficiencies and completed courses
- It must provide a way for them to look at future semester course offerings in both a long-term overview and with immediate detailed course descriptions as depicted in Figure 3.
- It must allow students to visually explore the impact of certain decisions. Students must be able to essentially perform simulations of various possible futures and be able to see the results and implications of these possible futures.

Interaction With The Planner

The basic layout of the user interface presents the user with several screen areas. One area shows a list of proficiencies including highlights for proficiencies that the current user has already accumulated. The central screen area is reserved for showing courses. This area shows courses that the user has already taken as well as courses which the user is currently able to take. Lastly we designate another screen area for displaying detailed text information on items that have been clicked on.

As we lay out this initial framework for a user interface it becomes clear that how we dynamically highlight various screen elements is a key aspect of the visual language we are designing. We have determined that the interactive behaviors of hovering and clicking are the key actions that users may take.

Prior to any interaction, the basic background visual interface will present the user with their own list of accumulated proficiencies as well as a list of all the courses they have completed. Based on which proficiencies the user has accumulated, it will illustrate which courses are currently possible to take by highlighting them in green. Courses that are "almost" possible to take are highlighted in yellow. Courses that cannot be taken are highlighted in grey.

In this application it is often necessary to present the user with visual cues to the relationships between various graphical elements. Users will see a grid display of all the courses offered in the following semesters. Hovering over any of these elements will highlight not only that element but also proficiencies required to take this course, and proficiencies that this course will provide as depicted in Figure 5. Alternatively, hovering over a proficiency will highlight all the courses which provide this proficiency as depicted in Figure 4. We rely heavily on this "linking and brushing" [3] interaction technique of interactively highlighting related elements.

Clicking on a course icon has the effect of simulating the impact of having completed this course. This changes its icon to illustrate that it has been pinned into a simulation. By "pinning" various combinations of courses in future semesters, students can explore the impacts such as other courses becoming available or not, as depicted in Figure 6.

Visual Design
For the visual design, we utilize four colors (Black, White, Green and Yellow) and two visual metaphors (Checkbox and Pin) to state the meaning of the statuses of each proficiency and course.
Only the "free" green courses can be pinned. The "pinned" courses are highlighted with a white frame and white triangular symbol. This action reveals future courses that the student can take if he or she successfully completes the "pinned" course - these courses are also bordered by a white frame.

Implementation and Discussion
The Visual Planner is implemented using HTML, CSS, JavaScript and jQuery. We use Ruby on Rails as a platform to collect data from and communicate with enrollment databases. Many course planners have been developed such as Rutgers course schedule planner [1] and the course timetable planner of Toronto University [2]. Also, other early manipulation retrieval systems, such as "FilmFinder", achieve a similar end using a visualization [7]. To the best of our knowledge, our visual planner is the first to operate within a curriculum designed around proficiencies rather than prerequisites using a visualization.

Conclusion and Future Work
In the future, we plan to run formal user studies to evaluate the quality of the design and the usability of the tool. At this point we have only informal user studies and user feedback but initial responses are very positive. The task of simplifying a very complex set of course relationships is not a simple one. If the tool is too simple, it will lose the flexibility and usefulness we need, but if it is too complex, then usability will suffer. We feel we have struck a good balance between complexity and usefulness in this tool which will be in use by the Digital Culture community in the spring of 2012.

References